Assessing magnetic bihelicity near the surface of the dynamo

August 23, 2019, Revision: 1.2

1 Introduction

All stellar dynamos have an outer surface, but it is not normally regarded an important ingredient, since one expects the magnetic field to decline smoothly toward the surface. However, the structure of the convection zone itself has a very discontinuous behavior toward the surface, because the convective length scale, which is expected to be proportional to the pressure scale height, decreases sharply toward the surface layers. Above the surface, the pressure scale height increases rapidly as the temperature reaches coronal values. The velocity here is insignificant and strongly controlled by the magnetic field. The effect on the dynamo-generated magnetic field is not obvious and may be rather counter-intuitive, if there is any effect.

Here we are interested in the scale dependence of the magnetic field in the proximity of the surface. What is meant by scale-dependence can be very much a matter of definition. If we think of this being the form of the Fourier spectrum a a function of the inverse wavenumber, we may get one answer, but if we think of scales being the typical scale in a wavelet decomposition, we may get another answer. Which of the two decompositions is better depends on circumstances.

In a completely homogeneous system, when the turbulent intensity and perhaps the kinetic helicity are statistically uniform, a Fourier decomposition is the most appropriate tool. On the other hand, near the surface, when the properties of the turbulence change drastically over scales short compared with the typical scale of the turbulence, a Fourier decomposition is prone to develop Gibbs phenomena and is therefore probably the worst possibly method. Wavelet transforms may then be more appropriate. Assessing the difference between these two treatments is the goal of the present paper.

The system we choose to study here is a turbulent dynamo driven by a random forcing function, whose amplitude is modulated by a tophat function. This means that the turbulent intensity falls off abruptly outside the dynamo-active region. Here we are particularly interested in the question of how the magnetic energy and helicity spectra change near the surface. In particular, we want to know how the relative importance of large and small length scales changes as we cross the surface. This may have important consequences for understanding apparent sign change of magnetic helicity with height, which has been discovered both in the solar wind (Brandenburg et al., 2011) and in various dynamo modes (Brandenburg et al., 2009; Warnecke et al., 2011, 2012).

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1. compute horiontal spectra at different heights
2. expansion in terms of other polynomials.
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References

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